Topic: Understand how Flares Accelerate Particles near the Sun (i.e., through Shocks and/or Reconnection) and how they Contribute to Large SEP Events

Project Title:
The Disappearance of Large, Fe-Rich Solar Energetic Particle Events in the Declining Phase of Cycle 23: Implications for the Role of Flares

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Project Information:
A large body of observations in the 1980s led to the formulation of a "standard model", by which solar energetic particle (SEP) events are divided into two categories, "gradual" and "impulsive". These names are short-hand for the likely sites and mechanisms of particle acceleration. Gradual events are those in which a preponderance of evidence points to acceleration at shocks driven by fast coronal mass ejections (CMEs). Impulsive events, on the other hand, are generally ascribed to particle acceleration at sites associated with flares, probably through resonant wave-particle interactions following magnetic reconnection. One of the defining distinctions between the two event categories is the event-integrated Fe/O ratio, with gradual events at a few MeV/nucleon exhibiting typical coronal values while impulsive events generally show strong enhancements. But the precise, comprehensive observations from a fleet of new spacecraft at the start of Cycle 23 immediately challenged this neat picture: Fe/O ratios generally varied with energy, and a large fraction of the nominally "gradual" events, when observed at energies above the few MeV/nucleon where the two categories had originally been developed, showed enhanced Fe/O ratios approaching those typically associated with impulsive events. In 1997-2002, 13 out of the 38 very large SEP events (identified by >30 MeV proton fluence above 2 x 10^5/cm^2-sr) had an Fe/O ratio above 30 MeV/nucleon that was at least four times the nominal coronal value. But in 2003-2005, zero out of the 20 events satisfying the same selection criterion displayed comparably large Fe/O enhancements. This dramatic shift clearly indicates that the condition(s) that allow flares to contribute to large SEP events have changed in some fundamental way in the declining phase of Cycle 23. Identifying the factors behind this shift is the focus of this proposal, which is submitted in response to LWS TR&T Focused Research Topic T3.e. In particular, several hypotheses have been developed in recent years in order to explain the flare-like composition seen at high energies in some large gradual events. For each of the pending hypotheses, one can draw inferences about how they would accommodate the late-Cycle disappearance of Fe-rich events. We propose to use flare, CME, radio, and SEP observations to investigate each of these inferences, in hopes of narrowing the field of viable hypotheses. Our work will thereby sharpen the objectives for future SEP studies by STEREO and Sentinels. In particular, this proposal will help to clarify the range of possible factors that drive the SEP origin in individual events, and thereby contribute to refining requirements and observation strategies for the Sentinels. This proposal addresses NASA Strategic Sub-Goals 3B.1, 3B.2, 3B.3, and 3C.4.

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